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ENVIRONMENTAL EVALUATION WORK PLAN (EEW) OPERABLE UNIT NO. 2 (903 PAD, MOUND, AND EAST TRENCHES AREA)

D R A F T

U.S. Department of Energy
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

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ENVIRONMENTAL EVALUATION WORK PLAN
OPERABLE UNIT NO. 2
903 PAD, MOUND, AND TRENCHES AREAS

1.0 INTRODUCTION

Under §106 of the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA" or "Superfund"), the Environmental Protection Agency (EPA) is mandated by the Congress to take appropriate action whenever "there may be an imminent and substantial endangerment to the public health or welfare <u>or the environment</u> because of an actual or threatened release of a hazardous substance from a facility" (emphasis added). This same language is employed in §104 although the concept of hazardous substance is broadened to include "any pollutant or contaminant." The EPA's mandate to protect human health and the environment is reiterated throughout CERCLA [e.g., §§121(b)(1), 121(c), and 121(d)] and its major implementing regulations which are contained in the National Oil and Hazardous Substances Contingency Plan (NCP) [40 CFR Part 300, Subpart F]. The NCP was extensively revised on March 8, 1990 (55 FR 8666) to incorporate requirements of the Superfund Amendments and Reauthorization Act of 1986 ("SARA"). It provides the overall framework for identifying and obtaining information on hazardous substance sites, assessing the nature and extent of the contamination, determining the risk to human health and the environment, evaluating and selecting remedial action technologies, and implementing decisions on remedial actions.

The requirement for the performance of "environmental evaluations" at CERCLA sites derives from NCP specifications for remedial investigations and feasibility studies (RI/FSs). The regulations in 40 CFR §300.430(e)(i)(G) provide as follows:

> Environmental evaluations shall be performed to assess threats to the environment, especially sensitive habitats and critical habitats of species protected under the Endangered Species Act.

This does not mean that environmental evaluations (EEs) are to be limited to assessing risks to threatened or endangered species of plants or animals.

Detailed guidance on conducting environmental evaluations is contained in the EPA "Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual." Although an "environmental evaluation" is specifically required by the NCP, the EPA uses the term "ecological assessment" as being a more precise description of the activities that actually take place in the environmental evaluation process. The EPA Manual defines an ecological assessment as "a qualitative and/or quantitative appraisal of the actual or potential effects of a hazardous waste site on plants and animals other than people and domesticated species" (EPA, 1989b). The EPA manual recognizes that ecological assessments may identify new or unexpected exposure pathways that may affect human populations.

Ecology is a branch of biological science devoted to the study of the interrelationships between organisms and their environment. In the context of any CERCLA site, human health is inextricably linked to the survival and physiological condition of nonhuman species. Thus, a risk assessment focusing on human health and an ecological assessment are, essentially, different sides of the same coin.

This Environmental Evaluation Work Plan (EEW) has been prepared for operable unit (OU) No. 2 (903 Pad, Mound, and East Trenches Area) at the U.S. Department of Energy (DOE) Rocky Flats Plant (RFP) near Denver, Colorado. The EEW provides a generalized overview of the site, establishes a purpose and objectives, addresses an environmental evaluation methodology, and identifies tasks to be undertaken as part of the environmental evaluation implementation process.

1.1 OVERVIEW OF ROCKY FLATS PLANT AND OPERABLE UNIT NO. 2

The RFP is a government-owned and contractor-operated facility that is part of the nationwide nuclear weapons research, development, and production complex administered by the DOE. The operating contractor for the RFP is EG&G Rocky Flats, Inc. The RFP produces metal components for nuclear weapons. These components are fabricated from plutonium, uranium, beryllium, and stainless steel. Additional production activities include chemical recovery, purification of recyclable transuranic radionuclides, and metal fabrication and assembly. Other activities include research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. Weapons parts made at the RFP are shipped elsewhere for final assembly. Plant operations generate nonhazardous, hazardous, radioactive, and radioactive mixed waste streams (Rockwell International, 1987).

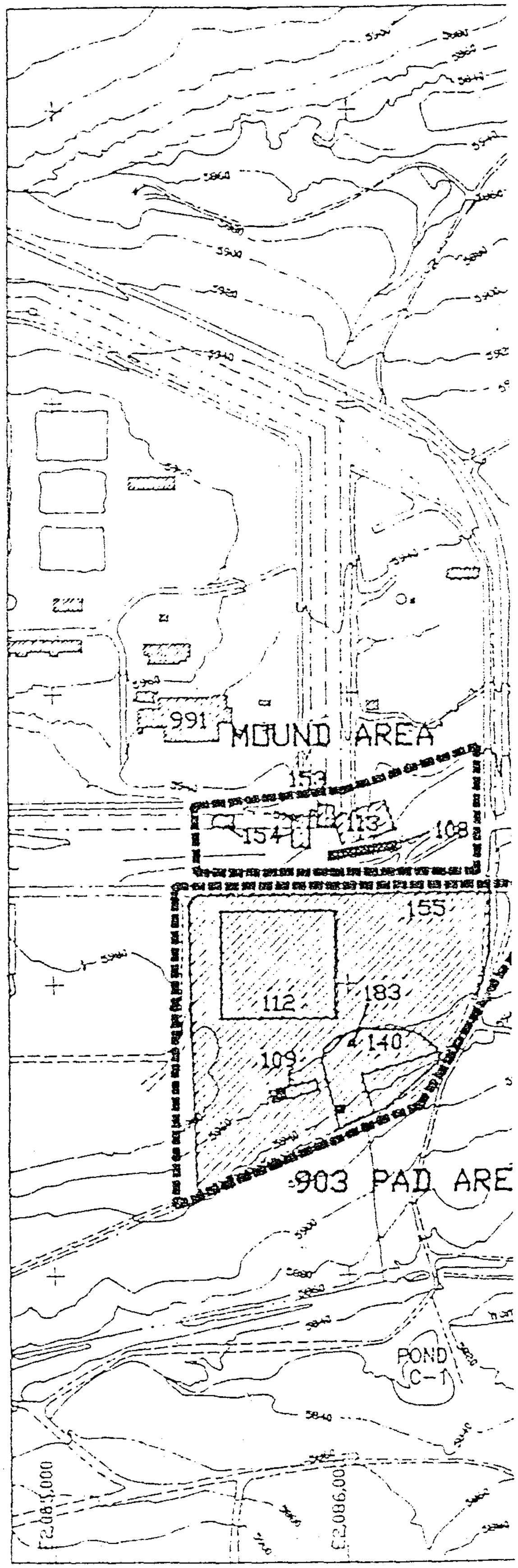
The RFP is situated on 6,550 acres of federal property 16 miles northwest of downtown Denver, Colorado. OU No. 2 is located on the southeast side of the controlled security area of the Rocky Flats Plant (Figure 1). (See EEW Subsection 1.1.1 for a definition of "operable unit.")

As part of the Phase II RCRA Facility Investigation/Remedial Investigation and Feasibility Study (RFI/RIFS) to be conducted for OU No. 2, a baseline risk assessment (BRA) will be performed to provide the basis for whether remedial action under CERCLA is necessary. The BRA will be comprised of two parts: the human health risk assessment and the environmental evaluation (or ecological risk assessment). Consequently, this EEW is an adjunct to the Phase II RFI/RIFS work plan.

The EEW prescribes how potential impacts or risks to the environment from existing OU No. 2 conditions will be evaluated, using in part the data collected during the Phase II RFI/RIFS. When the EE is implemented, it will identify and characterize the toxicity and levels of hazardous substances present, the fate and transport of contaminants, and the potential for environmental exposure (to plants and animals).

1.1.1 Rocky Flats Environmental Restoration (ER) Program

The DOE, EPA Region VIII, and the State of Colorado entered into a draft Rocky Flats Federal Facility Agreement and Consent Order (Agreement) (FFCA) in December 1989.



EXPLANATION

216.2 SOLID WASTE MANAGEMENT UNIT (SWMU) AND SWMU DESIGNATION

REMEDIAL INVESTIGATION AREAS

N

Scale: 1" = 600'

0' 300' 600'

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

FIGURE 1
OPERABLE UNIT NO. 2
903 PAD AREA, MOUND AREA,
AND EAST TRENCHES AREA

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The draft Agreement, more generally referred to as the Interagency Agreement (IAG), describes the general response processes for hazardous substance sites at the RFP. Environmental response activities performed by the DOE under the IAG are to be consistent with the CERCLA/SARA, NCP, the Resource Conservation and Recovery Act (RCRA), the Colorado Hazardous Waste Act (CHWA), the National Environmental Policy Act (NEPA), the Atomic Energy Act of 1954, and other applicable federal and State laws and regulations. The IAG formulates the scope of a phased approach for environmental restoration tailored to meet the specific requirements of the RFP. The environmental response activities under the IAG are managed by the RFP Environmental Restoration Program.

The 178 Individual Hazardous Substance Sites (IHSSs), also know as Solid Waste Management Units (SWMUs), are grouped into 16 operable units. The IAG includes a specific response program for each OU as well as a number of site-wide environmental monitoring and response activities. A recent renegotiation of the IAG has resulted in a renumbering of the operable units to reflect the priority of the units in terms of potential environmental risks. The new OU numbers are used in this EEW. OU No. 2 consists of 18 IHSSs or SWMUs grouped into three general areas designated as the 903 Pad Area, the Mound Area, and the East Trenches Area.

In addition to the response activities to be proposed for each OU, there are several site-wide environmental restoration activities which collect information or are otherwise relevant to this EEW:

- Community Relations Plan
- Health and Safety Plan
- Plan for prevention of contaminant dispersion
- Treatability studies
- Quality Assurance Program
- Ground water monitoring program
- Surface water monitoring program
- Baseline wildlife studies
- Background geochemical characterization.

Several other operable units are geographically related to OU No. 2. The drainages downstream of OU No. 2 are separate operable units: Woman Creek, OU No. 5, Walnut Creek, OU No. 6. Other operable units which are situated in close proximity to OU No. 2 include the 881 Hillside (OU No. 1) and several SWMUs included in the Other Outside Closures (OU No. 10), the 100 Area (OU No. 13), and the Low Priority Sites (OU No. 16). This EEW assumes that issues relating to commingling of contamination of OU No. 2 units with that for other operable units will be resolved by the RFI/RIFS.

A Phase I Remedial Investigation (RI) has already been conducted for OU No. 2, making available site information regarding soils, ground water, and surface water (Rockwell International, 1987). The planned Phase II RFI/RIFS is to be subdivided into two components: alluvial and bedrock. The Phase II RFI/RIFS (alluvial) will further characterize sources and the extent of contamination in the uppermost aquifer (surficial materials and subcropping sandstones). Available site characterization information on contamination is summarized in the Phase II RFI/RIFS (Alluvial) Work Plan (DOE, 1990a). The Phase II RFI/RIFS (Bedrock) Work Plan is scheduled for preparation in late 1990. As stated earlier, the Phase II RFI/RIFS will include a human health risk assessment and an EE.

R

An interim remedial action is being planned to treat contaminated water in South Walnut Creek north of OU No. 2 (EG&G, 1989). A final remedial action may be proposed based on the Phase II investigation results, the risk assessment, and the EE. The EE will address the potential environmental impacts associated with OU No. 2 under the "no-action" alternative (no remedial action taken). The EE will use the data collected in the RFI/RIFS process and supplement the data as necessary. The EE will also provide environmental information needed to evaluate the mitigation of the environmental risks, if any, by various alternative corrective measures or remedial actions considered in the Feasibility Study.

The EE will be conducted according to the EPA Environmental Evaluation Manual previously referenced. The collected environmental data will be used to determine the bioavailability and toxicity of the contaminants to the flora and the fauna of the OU No.

2 area. Identification of the contaminants of concern and the environmental pathways for exposures to biota and fauna will aid in the selection of site remedies.

1.1.2 Site Background and Description

The 903 Pad and Mound Areas lie within the southeast portion of the 400-acre controlled area of the RFP, where all the production buildings are located. The East Trenches Area lies just to the west of the controlled area. Pathways which will be considered in the EE are air, ground water, surface water, soils, sediments, animal organisms, and vegetation.

The OU No. 2 areas are positioned on the east end of the Rocky Flats mesa in the watersheds of Woman Creek and South Walnut Creek. South Walnut Creek drains into Great Western Reservoir and Woman Creek drains into Standley Reservoir. Some runoff from OU No. 2 is routed by stormwater diversions.

Soils at OU No. 2 consist of Rocky Flats Alluvium which covers the mesa top. Soils on the sideslopes of the mesa are predominantly colluvium with minor terrace areas consisting of Verdos Alluvium and Slocum Alluvium. The creek valleys contain narrow areas of recent valley fill soil deposits and occasional small outcrops of the underlying Arapahoe Formation bedrock. The Arapahoe consists mainly of claystone with some sand beds.

Unconfined ground water flow occurs in the surficial deposits and the shallow bedrock in directions generally parallel to the ground surface topography. Confined ground water flow occurs in the deeper bedrock sandstones. The shallow ground water discharges to the surface as seeps along the edge of the mesa where the contact between the base of the Rocky Flats Alluvium and the bedrock occurs and as well as lower on down the hillslopes.

The vegetation on the east side of the RFP is characterized primarily by meadow-type habitat. Limited areas of marsh and stream-bank vegetation occur along the creeks (DOE, 1980).

At OU No. 2, contamination has been observed in the surface soils, in downhill seeps, and in unconfined ground water. Surface soils in the area are contaminated with plutonium, americium, and other radionuclides due to wind dispersal of particulates during clean-up of the 903 Drum Storage Site in the late 1960s (EG&G, 1989). Unconfined ground water is contaminated with volatile organics consisting primarily of carbon tetrachloride, tetrachloroethene, and trichloroethylene. Other constituents above background levels in the unconfined ground include trace metals, major cations and anions, total dissolved solids, uranium 238, and possibly plutonium and americium (EG&G, 1989). Discharge of unconfined ground water occurs as evapotranspiration, as seeps at the edge of the mesa, and to surface water in the creeks. Site contaminants have been identified in many of the seeps (EG&G, 1989).

1.2 GENERAL APPROACH

An environmental evaluation (or ecological assessment) has much in common with the basic elements of a human health risk assessment. A risk assessment is, simply, a process for analyzing the likelihood an adverse effect will occur, the magnitude and intensity of that effect, and its spatial and temporal distribution. The basic steps in CERCLA site risk assessment for determining risk to either human populations or the environment are, basically, the same: contaminant identification, exposure assessment, toxicity assessment, and risk characterization. In an ecological assessment, this is accomplished through evaluating site characteristics, determining the nature and extent of contamination, identifying the potential for exposure of plants and animals to contaminants, selecting ecological measurement "endpoints," and developing and implementing a sampling and analysis plan.

This EEW undertakes a comprehensive approach to performing an ecological assessment including establishing objectives, developing an overall investigation methodology, implementing the workplan, and producing and documenting the results. As stated earlier, the EEW is based on guidance provided in the EPA EE Manual (EPA, 1989b) and other guidance documents (see list of examples in Table 1 and the List of References at the end of Section 4.0).

TABLE 1

EXAMPLE U.S. ENVIRONMENTAL PROTECTION AGENCY AND U.S. DEPARTMENT OF ENERGY GUIDANCE DOCUMENTS AND REFERENCES FOR FIELD INVESTIGATIONS AND ENVIRONMENTAL EVALUATIONS

DOE, 1988, "Comprehensive Environmental Response, Compensation, and Liability Act Requirements," DOE Order 5400.YY, Draft September 1988.

DOE, 1988, "Radiological Effluent Monitoring and Environmental Surveillance," DOE Order 5400.XY, Draft September 1988.

DOE, 1988, "Radiation Protection of the Public and the Environment," DOE Order 5400.XX, Draft March 1988.

EPA, 1989, "Risk Assessment Guidance for Superfund Volume II Environmental Evaluation Manual, Interim Final," Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-89/001.

EPA, 1989, "Ecological Assessment of Hazardous Waste Sites," Environmental Research Laboratory, Corvallis, Oregon, EPA 600/3-89/013.

EPA, 1989, "Exposure Factors Handbook."

EPA, 1988, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final," Office of Emergency and Remedial Response, Washington, D.C., EPA/540/G-89/004.

EPA, 1988, "Superfund Exposure Assessment Manual," Office of Emergency and Remedial Response, Washington, D.C., EPA/540/1-88/001.

EPA, 1988, "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites," Office of Emergency and Remedial Response, Washington, D.C., EPA/540/G-88/003.

EPA, 1988, "Technological Approaches to the Cleanup of Radiologically Contaminated Superfund Sites," Office of Research and Development, Washington, D.C., EPA/540/2-88/002.

Oak Ridge National Laboratory, 1986, "User's Manual for Ecological Risk Assessment," Environmental Sciences Division Publication No. 2679, ORNL-6251.

A comprehensive methodology for performing an EE is detailed in Section 2.0 of this EEW. The procedures recommended provide a means of determining and measuring ecological risks in a systematic, controlled, and step-by-step manner that can be used in subsequent efforts to reduce or manage the risk. While the EEW structures the methodology for conducting the environmental evaluation for OU No. 2, it does not attempt to define the unit either in terms of contamination extent or ecological characteristics; this will be accomplished during the actual implementation of the EEW.

This EEW also provides a framework for determining additional data needs and identifying the techniques (including sampling and analysis) to be employed in determining ecological risks. It provides a means for both quantitative and qualitative estimates of ecological effects such as reductions of biological growth, productivity, and population changes.

By implementing the methodology described in Section 2.0 of the EEW, the subsequent EE will be able to determine the nature and extent of adverse effects on local ecosystems resulting from contaminants present at OU No. 2. Depending on the adequacy of the database, the ecological assessment has the potential for use of statistical, stochastic models to quantify the relationship of initial events (e.g., contaminant release) with probable ultimate effects (ecological consequences).

One caveat to this approach to the EE is that those developing the EEW have not yet had the opportunity to conduct a field reconnaissance of OU No. 2 and its environs because the unit is in a controlled, restricted area. Also, data that may exist pertaining to OU No. 2 will be collected and evaluated as part of the task of actually performing the environmental assessment (see EEW Subsection 3.2.1).

1.3 SCOPE OF THE ENVIRONMENTAL EVALUATION WORK PLAN

The principal focus of the EEW is on the basic methodology for performing an ecological assessment as described in EEW Section 2.0. This is because an understanding of the methodological environmental assessment process is critical to implementing the tasks described in EEW Section 3.0. Although the methodology may appear to be abstract in some respects because of the absence of complete RFI/RIFS data on OU No. 2, the ecological assessment process prescribed has been used at other sites and in other situations and is generally accepted by the scientific community.

The basic components in the EE methodology described in this EEW are:

(1) Data evaluation and analysis, including nature and extent of contamination and site characteristics

(2) Environmental analysis, including ecosystem characterization, field investigations, sampling and analysis, and pathway analysis

(3) Toxicity assessment which estimates exposure and dose, and selection of endpoints or biomarkers

(4) Risk characterization according to criteria for organic chemicals, heavy metals, and radionuclides.

The environmental evaluation, as described in the EEW, will also draw conclusions about whether or not the objectives of the evaluation were achieved and identify the limitations of the analysis.

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EEW implementation is presented in Section 3.0 as separate tasks for managing and conducting the EE for OU No. 2. The implementation plan will be used to schedule and estimate the cost of the entire EE process as well as to control the structuring and implementation of the various tasks. The ultimate scope of the EE is contingent on the availability of existing data and on the progress of the field investigations; it should be reviewed regularly as the evaluation process proceeds. Section 4.0 of the EEW addresses the various types of documentation that will result from the EE process, including the Environmental Evaluation Report (EER).

1.4 PURPOSE AND OBJECTIVES OF THE EE

The overall purpose of an EE of the OU No. 2 area is to document a qualitative and, where possible, a quantitative assessment of actual or potential threats of damage to the environment including protected wildlife and vegetation species, habitats, or sensitive ecosystems. This purpose is consistent with the mandates of CERCLA/SARA and the IAG which states in Part 3 that one of its purposes is to ensure that "an appropriate response action is taken and completed as necessary to protect the public health, welfare, and environment." The purpose of the EE Work Plan is to establish a scientifically credible procedure to be followed and implemented during the performance of the EE for OU No. 2.

The EE will provide decisionmakers with information required to determine risk to the environment associated with contaminant migration from OU No. 2 as it exists and if nothing is done to remediate the site. It can also be used to determine whether or not contamination at OU No. 2 requires remedial action and to predict potential effects of those actions on the environment. In addition, the EE can suggest future strategies for monitoring the effectiveness of any remediation accomplished at or near the site.

The environmental evaluation for OU No. 2 has multiple objectives. They are to determine:

- Ecological characteristics of OU No. 2 and its area of influence
- Kinds, forms, and quantities of contaminants of concern
- Means of potential or actual release of contaminants
- Habitats potentially affected and populations potentially exposed to contaminants
- Exposure pathways to potentially sensitive populations
- Actual or potential ecological effects and the overall nature of the risk.

2.0 ENVIRONMENTAL EVALUATION METHODOLOGY

This section identifies and discusses the principle components of the Environmental Evaluation for OU No. 2. They are presented in the sequence that would normally be followed in performing an ecological assessment. The major portion of the EE will be devoted to assessing ecological risks: environmental analysis (Subsection 2.2); toxicity assessment (Subsection 2.3); and risk characterization (Subsection 2.4).

2.1 DATA EVALUATION AND ANALYSIS

Site-specific (RFP) and operable unit specific (Operable Unit No. 2, 903 Pad, Mound, and East Trenches Areas) data and information collected during the Phase I RFI/RIFS program and prior studies by DOE and the RFP operating contractors will be reviewed and evaluated. Likewise, reports on the general area and scientific information on ecological processes related to this assessment (e.g., mobility of uranium in aquatic ecosystems) will be reviewed. These data and reports will be collected, analyzed, and complied as source documents. The principal objective of this effort is to determine what existing data/ information can be used for the EE, and define additional data requirements. The Phases I and II RFI/RIFS programs should provide the majority of the site-specific data needed on surface water, ground water, soils, and air quality. Previous environmental studies should provide the general ecological information. However, site-specific ecological data and estimates of contaminant and energy transfer in the OU No. 2 area will likely require additional investigations.

In addition to the documents listed in Table 1, the following sources will be used to acquire information:

- Project files maintained by Rockwell International and EG&G
- Project reports and documents on file at the Front Range Community College Library and the Colorado Department of Health
- DOE documents and DOE orders
- The Phase I RFI/RIFS database

- Studies on radionuclide uptake, retention, and effects on plant and animal populations conducted by the University of Colorado and Colorado State University
- The scientific literature, including ecological and risk assessment reports at DOE facilities: Oak Ridge National Laboratory, Los Alamos National Laboratory, and the Savannah River Project.

Several of the scientific reports that will be used are cited in various subsections of this EEW, including the Phase II RFI/RIFS Work Plan for Operable Unit No. 2 (DOE, 1990a), the Final EIS on the Rocky Flats Plant (DOE, 1980), and the RFP Solar Evaporation Ponds Closure Plan (Rockwell International, 1988). The references cited in this EEW are presented at the end of Section 4.0.

2.2 ENVIRONMENTAL ANALYSES

The biotic and abiotic components of the existing ecosystems will be described and analyzed to determine the impacts associated with the release of contaminants. This analytical process includes characterizing the principal ecosystems in the area (Subsection 2.2.1), determining which biological populations are at risk (Subsection 2.2.2), and identifying the exposure pathways to biological receptors (Subsection 2.2.3).

The environmental analysis will be coupled with the data evaluation and analysis process (Subsection 2.1) to determine specific data/information requirements for completing the EE. The field investigations, sampling, and analytical work to be undertaken to fill these data gaps are discussed in Subsection 2.2.4.

2.2.1 Ecosystem Characterization

The ecosystems at the Rocky Flats Plant site in the high plains region along the foothills include arid grasslands on alluvial flats and fans interspersed with creek drainages and riparian zones. Ponds and canals have been constructed within the drainages and offsite for runoff control and water retention purposes. These ecosystems will be inventoried and described to characterize the biotic resources within the RFP area.

In general, there are three levels of ecological organization to be characterized: populations, communities, and ecosystems. Each level has its own dimensions of extent, structure, and change. This EE will place more emphasis on assessing impacts at the population and community levels. For example, population dynamic parameters such as mortality and recruitment, and community endpoints such as species diversity and productivity, will be used to assess the impacts of contaminants. In determining the effects of the contaminants on biota, an understanding of the chemical, energy, and nutrient cycles in the ecosystems will be necessary to describe and analyze contaminant uptake and fate in the food chains.

The ecosystem characterization process includes inventorying and characterizing the terrestrial and aquatic biota in the area, describing the habitats that support the growth and existence of these biota, and defining the flow of nutrients and energy through the food webs of the ecosystem.

F

Flora and Fauna

Field investigations and existing reports will be used to determine which plants and animals make up the biological components of the ecosystems at the RFP. The primary objective will be to provide the best possible estimates of populations in the area, commensurate with the accessibility of study areas and the time and personnel available. The amount, type, reliability, and currency of the data may vary according to species, time, and place. A complete inventory of all species will not be attempted. Rather, certain species and populations will be selected for study based on criteria including, but not limited to, the following:

- Value as habitat quality indicators
- Local significance and public interest in the species/population
- Potential for the species/population to be impacted, and the ease of measuring the impact or stress
- Potential future conflict with RFP operations or remediation activities

- Critical nature of the habitat or sensitivity of the species/population (e.g., wetlands or threatened/endangered designations).

Each species or population selected for detailed study will be inventoried as often as is necessary to properly evaluate procedures and to maintain meaningful historical records. The goal will be to produce inventory information with the degree of reliability needed to effectively evaluate impacts at the environmental level.

Habitats

Available habitat is defined as the surface area capable of providing direct life support for an evaluation species (U.S. Fish and Wildlife Service, 1981b). The areal extent and potential for impacts resulting from contaminants at OU No. 2 on available habitats will be assessed.

Factors which may potentially affect habitats present at the Rocky Flats Plants would be addressed. These include:

- Direct or indirect exposure to site-related contaminants due to transport from the source
- Physical disruption of ecosystem processes due to contaminant interference with natural biochemical, physiological, and behavioral processes
- Physical disruption of the habitat due to the site's design or operation
- Physical or chemical disturbances or destruction due to cleanup or remedial activities
- Other stresses not directed related to the site, such as extreme weather conditions.

Food Webs

Energy and nutrients flow through ecosystems by means of complex interactions between organisms known as food chains and food webs. Food chains describe the transfer of energy and nutrients from one organism to another as one consumes or decomposes the other. Food chains selected for the EE will represent of the five major trophic levels:

- Primary producers

- Primary consumers (herbivores)
- Secondary consumers (omnivores)
- Tertiary consumers (carnivores)
- Decomposers.

Food webs are interconnecting food chains. Food webs more realistically describe the complex system of pathways by which the flow of energy and nutrients take place in nature. A general discussion will be included to explain how the selected food chain(s) interrelate with the aquatic and terrestrial ecosystems found at the RFP and in the vicinity of OU No. 2.

2.2.2 Populations at Risk

The terrestrial and aquatic flora and fauna in the RFP area have been described by several researchers (Weber et al., 1974; Clark, 1977; Quick, 1964; Winsor, 1975) and summarized in the Final Environmental Impact Statement for the Rocky Flats Plant Site (DOE, 1980). Species lists are presented in the Appendix of this EIS. In addition, terrestrial and aquatic radioecological studies conducted by Colorado State University (Rockwell International, 1986; Johnson et al., 1974; Whicker, 1979; Little, 1976, and Hiatt, 1977) and annual monitoring programs at RFP have provided information on the plants and animals in the area and their relative distribution.

The above resources, discussions with RFP and Colorado Division of Wildlife (DOW) personnel, and on-site surveys will be used to determine the presence and distribution of plants and animals with respect to OU No. 2. Distribution of plants and animals within, upgradient, and downgradient of the unit will be defined to fine-tune the ecological impact assessment approach and sampling plans. The process of determining which populations are at risk involves selecting specific groups of organisms (e.g., benthic macroinvertebrates and prairie grasses), target species (e.g., fathead minnow and deer mice), and critical habitats (e.g., wetlands).

Target species, target communities, and critical habitats will be selected using the following criteria:

- Susceptibility of the species, community, or habitat to the contaminants associated with OU No. 2
- Relationships between the target species, community, or habitat and the exposure pathways
- Degree of difficulty in accurately measuring the desired endpoint in that species or community
- Ability to define adequate reference and onsite test areas for the target community
- Amount of information in the scientific literature on the target species, community, or habitat.
- Degree of difficulty and costs involved in conducting the necessary field sampling and laboratory analytical programs
- Potential for bioaccumulation or biomagnification of the contaminant of concern in the target species or community
- Prior success with biomarkers, based on the scientific literature, for the target species.

Based on a preliminary review of the information available, some likely target species, communities, and critical habitats are presented in Table 2.

Wetland habitats, rather limited in the RFP area, are known to be productive habitats that support a relatively diverse assemblage of plants and animals. Wetlands, therefore, will be considered a critical habitat for this EE. Threatened and endangered species automatically fall within the "populations at risk" category and deserve special attention. However, prior studies indicate there may be no federally listed threatened or endangered species within the boundaries of the RFP (DOE, 1980, 1990b). The conclusions of these studies will be confirmed (or not confirmed) in the field. The project staff will also consult with the Colorado DOW to determine if there are any species of special concern from the State's perspective.

TABLE 2

POTENTIAL TARGET SPECIES, PLANT AND ANIMAL COMMUNITIES, AND HABITATS FOR ASSESSMENT OF ECOLOGICAL IMPACTS AT THE RFP OPERABLE UNIT No. 2

Community	Species/Organism	Community	Species/Organism
Periphyton	Diatoms	Small Carnivores	Long-tailed Weasel
	Green Algae		Meadow Vole
	Blue-Green Algae		Bull Snake
Benthic Macroinvertebrates	Mayflies	Large Carnivores	Red Fox
	Caddis Flies		Coyote
	Chironomids	Grasses	Big Bluestem
Fish	Fathead Minows		Side-Oats Grama
	Redside Dace		June Grass
	Bluegill	Shrubs/Forbes	Yucca
Herbivores	Mule Deer		Wild Plum
	Jack Rabbit		Nodding Thistle
	Deer Mice	Trees	Juniper
	Northern Pocket Gopher		Cottonwood
		Wetlands	Willows
			Cattails
			Sedges

2.2.3 Pathway Analysis

An exposure pathway determines how a contaminant can move from its source to a receptor in the environment. A complete exposure pathway has five components:

1. Contaminant source
2. Mechanism for contaminant release
3. Environmental transport medium
4. Exposure point (receptor location)
5. Route of exposure.

To qualify as a potential exposure pathway, all components of the pathway must be present. Numerous possible exposure pathways from the sources within OU No. 2 to plants and animals in the area will be assessed and several pathways will be selected for detailed analysis. The selected pathways will represent actual field conditions.

It is anticipated that many exposure pathways cannot be quantified because transport rates, intake rates, or other data are not available. Target species will be selected from the endemic fauna at the RFP. Exposure pathways selected for analyses will include some or all of the target species. Pathways will be developed for the five transport media: air, soil, ground water, surface water, and sediments.

The logical exposure points at and near OU No. 2 will be identified. These will be based on the environmental fate modeling of the release of contaminants from on-site sources and the identification of biota likely to be present within the immediate location. The chemical transport and fate of contaminants will be evaluated using procedures in the EPA Superfund Exposure Assessment Manual (EPA, 1988).

Many of the potential human exposure routes for constituents of concern at the RFP also exist as possibilities for the endemic wildlife population. These include inhalation of volatilized contaminants in air, inhalation of dust from contaminated soils, and dermal exposure to contaminated surface waters and soils. Since wildlife on or near the RFP derive a major portion of their food supply from vegetation or prey species near the plant, migration of constituents into the food web with the subsequent possibility of biomagnification may provide a significant indirect route of exposure.

Quantitative analysis will be completed by using established EPA models for rate of transfer and fate of contaminants (EPA, 1988) and for calculating specific intakes for each target species selected for quantitative evaluation. Standard equations for estimating human intakes (EPA, 1989a) may be used, where appropriate, to estimate intake rates for terrestrial vertebrates.

The exposure pathway portion of the EE will seek to answer the following questions, using site-specific data and available information in the scientific literature:

- What receptor(s) are actually or potentially exposed to contaminants from the RFP?
- What are the significant routes of exposure?
- To what concentrations of each contaminant are the receptor(s) actually or potentially exposed?
- How long is each exposure?
- How often will the exposure(s) likely take place?
- What seasonal and climatic variations are likely to affect exposure?
- What are the site-specific geophysical, physical, and chemical conditions affecting exposure?

2.2.4 Field Investigations, Sampling, and Analysis

Because field investigation methods and sampling and analysis techniques are so critical to the scientific credibility of the EE, this section devotes a detailed discussion to these topics. Qualitative field surveys (Subsection 2.2.4.1), comparative ecology studies (Subsection 2.2.4.2), toxicity testing (Subsection 2.2.4.3), and bioaccumulation/biomarker studies (Subection 2.2.4.4) are addressed. Sampling procedures are addressed in Appendix C.

A preliminary assessment of the operational history of the RFP and OU No. 2, and a review of pertinent site characterization sections in available reports, indicates that completion of the EE requires:

1. Source characterization including presence, absence, and concentration gradients of contaminants

2. Exposure pathway characterization including contaminant release, media transport, and receptor exposure mechanisms

3. Presence, absence, and distribution of receptors

4. Assessment of toxicity or stress on the terrestrial and aquatic ecosystems present at the site.

The physical and chemical data required to address items 1 and 2 above, with few exceptions, will be available from the Phases I and II RFI/RIFS field investigations. One exception is that additional data on sediments adjacent to and downgradient of OU No. 2 will be collected to supplement planned investigations of potential impacts on aquatic ecosystems.

In order to address items 2, 3, and 4 above, additional data must be acquired on the flora and fauna in the area. The general biological components of the RFP area have been described by previous investigations (DOE, 1980, 1990b). However, more site specific data (i.e., specific to OU No. 2) and a more thorough understanding of the population and communities dynamics are necessary to complete the EE. For example, location-specific information on species diversity, biomass, cover class, and production within prairie grass communities at uncontaminated reference areas and at contaminated areas near OU No. 2 will be used to assess ecological risks.

The EE sampling methods will conform to the guidance manuals and sampling protocol references listed in Table 1 and the references cited at the end of Section 4.0. Evaluation techniques will include qualitative field surveys, comparative ecological studies, toxicity assessment/testing, bioaccumulation studies, and possibly biomarker investigations. Each of these techniques contributes a different type of information to the evaluation.

Information from the different techniques will be used to accumulate weight-of-evidence to support conclusions.

2.2.4.1 Qualitative Field Surveys

Field surveys will be conducted early in the process since the main objective is to get site-specific information on the occurrence of flora, fauna, and habitat types in order to fine tune sampling programs and complete a "reality check" on exposure pathways. Field surveys will also be used to select the best locations for reference (control) sampling areas. The field surveys will be conducted by qualified terrestrial and aquatic ecologists and will be largely qualitative. Some field instruments, such as pH and conductivity meters, will be used to assist in locating potential contaminant impacted areas, but most information will be acquired through visual observations. Details of field observations will be recorded in field logbooks.

Field biologists will: record all observations of animal sightings and animal signs such as nests, burrows and scat; record locations of any sensitive habitats and wetlands; and note any evidence of stressed vegetation or visual evidence of contamination. They will also access the suitability of different habitat types to support aquatic and terrestrial communities.

2.2.4.2 Comparative Ecology Studies

Ecological field surveys, involving comparisons of impacted and nonimpacted areas, are a definitive way of establishing that ecological impacts have occurred. However, care must be taken to account for differences in the physical/chemical aspects of the reference and test areas and the natural variations exhibited by biological populations. Qualified ecologists and toxicologists will select the ecological "endpoints" used to assess contaminant impacts. To maintain a valid comparison, reference areas or sites will be selected that: (1) are in close proximity to the RFP area; (2) closely resemble the RFP in terms of topography, soil composition, water chemistry, etc.; and (3) have no apparent exposure pathways from RFP or other sources of contamination.

Comparative ecological studies will be directed at two aquatic and one terrestrial community: benthic macroinvertebrates, periphyton, and prairie vegetation. These communities were selected because:

- There is extensive scientific literature available for interpreting results and making conclusions.
- The communities exist in impacted and nonimpacted areas of the RFP.
- Standard field techniques have been developed to measure the necessary community parameters.
- Surveys can be completed at reasonable costs.

Parameters such as relative abundance, species diversity, community organization, biomass, reproduction, and growth rates will be used to compare the communities at reference (nonimpacted) sites with communities in contaminated areas in or near the operable unit. Reference and contaminated sites will be carefully selected to minimize the influence of chemical and physical differences between the sites.

The periphyton communities at reference and test sites will be monitored using standardized artificial substrate samplers. Colonization during a predetermined exposure time will provide a measure of production, and chlorophyll per unit area will be used to estimate standing crop. Periphyton biomass, relative abundance of algae types, and other community indices will be used to compare the periphyton communities at the two areas. Physico-chemical parameters such as substrate type, water temperature, current velocity, and dissolved nutrients will be carefully documented.

Benthic macroinvertebrate communities at reference and test sites (likely different than the periphyton sampling sites) will be sampled using Surber samplers in riffle areas and an Ekman or Ponar grab in pool areas. Replicate samples will be collected at each site. Benthic invertebrates will be identified to the lowest practical toxionomic level and relative abundance of tolerant and intolerant species, species diversity, total biomass, and indices of community similarity will be used as assessment endpoints.

Vegetation surveys of prairie grass areas will be conducted by establishing transects in reference and contaminated areas and sampling square-meter or smaller plots at set intervals along the transects. Species abundance, cover class, biomass, and signs of stress will be used as assessment endpoints.

2.2.4.3 Toxicity Testing

The actual or potential toxicity of contaminants at stations within and near OU No. 2 will be assessed using three approaches: comparison of contaminant concentrations at exposure points to applicable or relevant and appropriate requirements (ARARs); comparison of existing concentrations to toxicological endpoints presented in scientific literature; and actual toxicity tests.

The initial step will be to compare average and maximum concentrations of contaminants of concern in air, soil, water, and sediments to established criteria. There are several well established criteria for aquatic ecosystems [e.g., Water Quality Criteria for Protection of Aquatic Life (EPA, 1986b)] but relatively few criteria for air, soils, and terrestrial ecosystems. The amount or proportion by which concentrations exceed available criteria will be presented in tabular form, and the ecological significance of the exceedances will be interpreted.

In some cases, toxicity values are available in the literature for chemicals that have no criteria or standards. Toxicity values for contaminants of concern (for plants and animals known to occur at the RFP), when available, will be compared to average and maximum concentrations of contaminants in air, soil, and water to supplement the information on exceedances of criteria. Again, more data on toxicity of aquatic organisms is expected to be available than on terrestrial organisms.

Comparison of on-site concentrations to criteria or toxicity values will not be sufficient to assess the potential impact of contaminants for which there are no criteria or toxicity values. Also, the comparison approach does not account for potential synergistic/ antagonistic effects in complex mixtures and may not adequately reflect the real bioavailability of the contaminant or the physico-chemical nature of the receiving waters. For this reason, a limited toxicity testing program will be conducted. The limited program may be considered an initial phase. If patterns of toxicity are encountered, a second phase of toxicity testing will be designed.

The initial toxicity testing program will be limited primarily to aquatic organisms and will include standardized acute and chronic tests with fathead minnows and Ceriodaphnia (EPA; 1985a, 1985b, 1985c). Water samples for toxicity tests will be collected from one station immediately downgradient of the 903 Pad Area, the Mound Area, and the East Trenches Area. Samples will also be collected from downstream stations on South Walnut Creek and Women Creek. Standard EPA methods will be used to conduct the acute and chronic (7-day fathead minnow and 7-day Ceriodaphnia tests) toxicity tests. The toxicity tests will be run during high-flow and low-flow conditions because the Phase I RFI studies have shown that there is considerable interaction between the surface and ground water systems at the RFP, and influence of ground water may vary significantly under different flow conditions.

The potential for a toxicity test involving soil and a terrestrial organism will be evaluated. If a relatively standard method is available using a species known to occur at the RFP toxicity tests will be conducted at reference and test areas. Toxicity tests developed for earthworms, crickets, and grasshoppers will be evaluated (EPA, 1989c).

2.2.4.4 Bioaccumulation/Biomarker Studies

One of the most direct techniques for assessing potential impacts from contamir .s on plants and animals is to sample appropriate organisms and measure the amount of the contaminant in various tissues (bioaccumulation). Bioaccumulation analyses will be conducted for selected metal and organic contaminants using periphyton, benthic macroinvertebrates, and prairie grass. The plants and animals will be collected during field sampling for the comparative ecological studies (Section 2.2.3.3). Because these organisms live in direct contact with the contaminated media (water, sediments, and soil), they are the most likely candidates to exhibit bioaccumulation. Samples will be collected from a limited number of stations that have exhibited prior contamination. If bioaccumulation is found to be occurring, the sampling program will be expanded.

Exposure to some metals such as cadmium and copper induces the synthesis of certain low molecular weight metal-binding proteins in a variety of vertebrate and invertebrate species. Thus, the measurement of these metal-binding proteins provides a potential tool for assessing the affects of these metals, or at least a sensitive tool for detecting when organisms are exposed to metals. As used in this EE, bioaccumulation is also considered a biomarker because it is a measurement of an endpoint in individual organisms that indicates exposure.

A review of the scientific literature will be conducted to determine if appropriate and reasonable biomarkers can be identified for species that exist in the RFP area. A specific biomarker approach will be developed if it appears to be a realistic technique for assessing environmental impacts at the RFP. Measurements of bioaccumulation, a biomarker technique, will be conducted as part of this EE and may be supplemented by other biomarker studies.

The term "biomarkers" refers to the measurement of selected endpoints in individual organisms, typically physiological or biochemical responses, that serve as indicators of exposure to contaminants and/or sublethal stress. For example, exposure to some metals such as cadmium and copper induces the synthesis of certain low molecular weight metal-binding proteins in a variety of vertebrate and invertebrate species. Thus, the measurement of these metal-binding proteins provides a potential tool for assessing the affects of these metals, or at least a sensitive tool for detecting when organisms are exposed to metals. As used in this EE, bioaccumulation is also considered a biomarker because it is a measurement of an endpoint in individual organisms that indicates exposure.

There are many advantages of using biomarkers in ecological assessments including: their broad applicability to many toxonomic groups; the ability to link field surveys to laboratory tests to interpret the significance of field results; and the fact that some biomarkers are diagnostic of specific contaminants. However, there is currently a lack of accepted, standardized, and tested biomarkers for many of the contaminants found at hazardous waste sites. Also, the relationship between a measured biomarker response and population-level effects has not been defined in many cases.

For the above reasons, the scientific literature will be reviewed early in the EE to determine if appropriate and reasonable biomarkers can be identified for the species that exist in the OU No. 2 area. A specific biomarker approach will be developed if it appears to be a realistic technique for assessing environmental impacts.

2.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to weigh the available evidence regarding the potential for particular contaminants to cause an adverse effect in exposed receptors (target species). It will also provide, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects. Toxicity assessments for contaminants identified at OU No. 2 will be accomplished by incorporating evidence from more than one technique, where possible. Specifically, the assessment of toxicity for plants and animals may include evidence from: a dose-response assessment (a standard approach in human health risk assessments); comparative ecological surveys using endpoints of ecological significance (such as an increase in mortality rate); or biomarker monitoring.

Many of the difficulties that arise during EE performance begin with the validity of techniques used to answer the seemingly easy question: Does a hazard exist? The term "hazard" should not be dealt with as an absolute. Its usage depends on the characteristics of the contaminant of concern and the circumstances of use. The Environmental Evaluation Report will clearly define this term and discuss techniques used in determining if a hazard(s) actually exists. An example toxicological profile is included in Appendix A.

2.3.1 Dose-Response Assessment (Extrapolation Models)

The most fundamental concept in toxicology is that a relationship exists between the dose of an agent and the response that is produced in a living organism. Dose-response assessment is the process of quantitatively evaluating the toxicity information and characterizing the relationship between the dose of the contaminant received and the incidence of adverse effects in the exposed populations. From this quantitative dose-response relationship, toxicity values (references doses, RFDs) are derived that can be used to estimate the incidence or potential for adverse effects as a function of receptor exposure to a contaminant.

Because individuals and species accumulate contaminants differently in their tissues, environmental concentrations and uptake rates will not necessarily predict biotic concentrations. Pharmacokinetic distribution following bioaccumulation determines the concentration of a constituent that actually reaches the physiological site of action within an organism, and therefore, the likelihood of an adverse effect. For this reason, concentrations in environmental media and biotic tissues will be determined independently for some species. Based on these data, site-specific bioconcentration factors (BCFs) may be derived. If site-specific BCFs cannot be derived from the monitoring data, published and/or predicted BCFs will be utilized in the EE.

The final step in the dose-response assessment will be to evaluate the toxicity associated with contaminants. For several chemicals, toxicological data have been evaluated by the EPA or other agencies and RFDs for noncarcinogenic effects have been developed (EPA, 1987d). These RFDs are based on a survey of the current toxicological literature including both animal studies and human epidemiological studies. In cases where RFDs are not available, comparisons may be drawn between the contaminant-receptor relationship existing at OU No. 2 and appropriate laboratory studies that have developed other values expressing toxicity. Examples include LD-50s, LC-50s, and growth inhibition levels.

Cancer potency factors have been developed for many contaminants that are carcinogenic in humans (EPA, 1987d). Similar factors or extrapolations have been made to some animal species. Carcinogenic potency factors are expressed as the lifetime cancer risk per mg/kg body weight per day. Therefore, exposures need to be quantified or estimated over long time periods. Where possible, the toxic effects of some contaminants will be assessed using cancer potency factors. Generally, this will be limited to vertebrate animals, and may be most appropriate for small mammals (e.g., mice) that have been the subject of, or test organisms in, numerous laboratory experiments on carcinogens.

2.3.2 Comparative Ecological Studies

Ecological surveys will be used during the EE to study endpoints of ecological interest in selected target species or plant or animal communities (see Subsection 2.2.4.2). These receptors (the target species or selected community) are the components of the ecosystem that may or may not be adversely affected by the site specific contaminant being studied. The measurement endpoints are the particular type of impact a contaminant is expected to have on a given receptor.

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Generally, endpoints of ecological interest may be divided into four levels: individual, population, community, and ecosystem. These levels may be further refined as:

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- Individual endpoints

R

  - changes in respiration
  - changes in behavior
  - increased susceptibility to illness
  - decreased growth
  - death

- Population endpoints

  - decreased genotypic and phenotypic diversity
  - decreased fecundity
  - decreased growth rate
  - increased frequency of disease
  - increased mortality rate

- Community endpoints

  - decreased species diversity
  - decreased food web diversity
  - decreased productivity

- Ecosystem endpoints

  - decreased diversity of communities
  - altered nutrient cycling
  - decreased resiliencies

Because of the complexity of interactions within food chains (or in a food web), and the number and variety of receptors in an ecosystem, it is impossible to assess the potential impacts to all receptors for all endpoints. Therefore, representative types of receptors and endpoints will be selected and used as indicators of potential effects on biological communities. Presently, there are no regulatory standards concerning individual assessment endpoints of biological interest for non-human aquatic or terrestrial species. There is, however, a general consensus defining adverse effects of measurement endpoints at the population level (EPA, 1989c) and, to a lesser extent, at the community level. Therefore, this EE will be limited to studying ecological endpoints in selected populations and communities (i.e., prairie grasses, benthic macroinvertebrates, and periphyton).

2.3.3 Biomarker Based Monitoring

The underlying concept for biomarker monitoring is that selected endpoints measured in individual organisms, typically comprised of biochemical or physiological responses, can provide sensitive indices of exposure or, more importantly, sublethal stress (see Section 2.2.4.4 on biaccumulation and biomarket studies).

Measures of bioaccumulation (i.e., chemical concentrations of a contaminant in organism) are frequently considered biomarkers of exposure. Other examples of biomarkers of exposure and sublethal stress include: (1) specific enzyme concentrations; (2) genetic abnormalities; (3) physiological responses; and/or (4) histopathological or skeletal abnormalities.

During the initial stages of the EE, the existing scientific literature on biomarker monitoring will be reviewed to determine if species common in the RFP area may be appropriate for this technique. For example, biomonitoring studies at Oak Ridge, Tennessee, associated with the environmental restoration program at the Oak Ridge

National Laboratory, have had some success using biomarkers (Loar, et al., 1988, 1989). Biomarkers would be selected on the basis of their sensitivity, reliability, and feasibility. The issue of sensitivity may be of particular importance because the key rationale of using biomarkers, particularly for sublethal stress, is the potential they have for detecting effects at earlier stages than most other approaches.

2.4 RISK CHARACTERIZATION

Information developed in the exposure and toxicity assessments (Subsections 2.2.2, 2.2.3, and 2.3) will be used to characterize the risk to plants and animals at the RFP from contaminants released from Operable Unit No. 2. The information will be summarized and integrated into quantitative and qualitative expressions of risk or dose. Comparisons will be made between projected intakes of chemicals (or other exposure estimates) and toxicity (as expressed by ARARs, toxicity test results, RFDs, or toxicity values from the literature) to characterize potential noncarcinogenic effects from exposure to chemical contaminants. To characterize potential carcinogenic effects from chemical contaminants, probabilities that an individual organism will develop cancer over a lifetime of exposure will be estimated from projected intakes and chemical-specific dose-response information. The assessment of carcinogenic effects will not be developed to the extent found in human health risk assessments; carcinogenic effects on only a few species will be presented. Estimated dose equivalents and intake rates will be compared to ARARs and other guidance to characterize potential effects from radionuclide exposure.

The risk characterization will present estimates of risk for defined exposure scenarios plus summaries of the relevant biological information, identification of the assumptions used and their limitations, and a discussion of uncertainties. The risk characterization will address risks associated with organic and inorganic (metals) contaminants and radionuclides.

2.4.1 Organic Contaminants

The toxicity of organic contaminants is both general and specific. Effects observed in studies of experimental animals have been dependent on a variety of factors including chemical structure, exposure level, frequency and coexposure, and subject sensitivity. Studies to date at the RFP, especially those specifically related to OU No. 2, indicate that volatile organic contaminants are much more prevalent than semi-volatile and base-neutral organics. There are relatively high concentrations of several volatile organics [e.g., trichloroethylene (TCE), tetrachloroethylene (PCE), carbon tetrachloride, vinyl chloride, and ethylbenzene] in various environmental media (soil, surface water, sediments, etc.). In contrast, Phase I RFI/RIFS sampling results indicate there are relatively few semi-volatile organics of concern.

Due to their high vapor pressure, volatile organics can be easily mobilized from one environmental compartment to another. They are very mobile in comparison to semi-volatiles and many inorganics; they can travel extensive distances in relatively short time periods. Kidney and liver enlargement are a common result of volatile organic toxicity because these chemicals induce mixed function oxidases. Prolonged exposure frequently results in damage to metabolic organs, and several volatile organics can induce carcinogenesis.

2.4.2 Inorganic (Metal) Contaminants

Toxicity of metals to aquatic organisms, plants, and soil-dwelling animals has been extensively researched, and scientific literature is available for assessing potential impacts. This is especially true for aquatic organisms.

There are a few general principles that contribute to understanding the pathophysiology of metal toxicity. Most metals affect multiple organ systems. The targets for toxicity are specific biochemical processes (enzymes) and/or membranes of cells and organelles. The toxic effect of the metal usually involves an interaction between the free metal ion and the toxicological target. There may be multiple reasons why a particular toxic effect occurs. For example, the metabolism to the toxic metal may be similar to a metabolically related essential element. Cells that are involved in the transport of metals, such as gastro-intestinal, liver, or renal tubular cells, are particularly susceptible to metal toxicity (Goyer, 1986).

The Phase I RFI/RIFS field investigations indicate that there are several metals in surface water, ground water, and soils at OU No. 2. Investigations are still in progress to determine which metals are present in concentrations exceeding expected natural background concentrations. However, it is likely that several metals which are toxic to plants and animals are contaminants associated with released from OU No. 2. For example, cadmium, chromium, zinc, and vanadium have been observed in several media at concentrations that are likely above background.

The water quality data from the Phase I and II RFI field investigations will be compared to the water quality criteria for the protection of aquatic life (EPA, 1986). Additionally, the information in EPA's 1986 Water Quality Criteria, the supporting Ambient Water Quality Criteria documents (e.g., zinc; EPA, 1987e), and the Contaminant Hazard Reviews (e.g., chromium; Eisler, 1986) will be used to evaluate the potential toxicity of metals to target species of aquatic plants and animals. The Ambient Water Quality Criteria documents also provide bioconcentration factors which can be compared, where available, to metal tissue residues in fish or macroinvertebrates.

The Contaminant Hazard Reviews and other toxicological literature will also be used to evaluate the potential toxicity of metals to terrestrial plants and animals, again emphasizing the information relative to the target species selected for this EE.

Toxicity tests for a limited number of target species may be conducted to supplement the toxicity evaluation based on comparing on-site concentrations to criteria. The comparison-to-criteria approach will not consider synergistic/antagonistic effects that can occur when certain metals are present at the same time, or the influence that organic contaminants or other substances may have on metal toxicity (see Subsection 2.2.4.3).

2.4.3 Radionuclides

The radionuclides of concern associated with OU No. 2 are plutonium and uranium with smaller amounts of americium (DOE, 1990). Other radionuclides that are potential contaminants in water are cesium-137, strontium-89, 90 and tritium. However, these three radionuclides may occur at concentrations only slightly above background.

The concentration level and dispersion of radionuclides from the RFP into air, soil, water, and biota have been studied and summarized in a report on the radioecology and airborne pathway at the facility (Rockwell International, 1986). Also, the ecological effects of plutonium in the environment at the RFP were assessed on biota by measuring biological parameters and by pathological examination (Whicker, 1979). The conclusions of these studies indicate that plutonium is relatively immobile in the environment, and that no differences in biological attributes could be related to plutonium levels found in environmental media at the RFP.

Specific ARARs for radionuclide contamination in environmental media are generally calculated for human health protection. These Derived Concentration Guides are based on the interim standard dose limit for all pathways of 0.1 rem/year for a 50-year effective dose equivalent. Very few studies have been conducted to relate the effects of radionuclides on non-human receptors. Most plant populations are much less sensitive than animal populations to radionuclides or their radiation. In most cases, the plants in the grasslands at the RFP are short-lived and turnover is rapid. Many wildlife are also short-lived, except for long-lived predator birds and mammals that may be sensitive to radiation effects. Soil invertebrates or anthropods may be sampled and used as indicators of plutonium uptake and possible bioaccumulation in the terrestrial environment. However, these populations have rapid turnover rates with respect to numbers, nutrients, and energy. They may not be good indicators of effects in most cases.

The aquatic ecosystems at the RFP may exhibit bioaccumulation of radionuclides. They will be sampled and evaluated during this EE. Previous sampling of aquatic communities in ponds and lakes near the RFP has revealed some bioaccumulation in seston (the mass of various living and nonliving substances in the water column) but, apparently, no transfer of plutonium within the food chain (DOE, 1990).

Literature searches will be conducted to locate toxicity studies on plant and animal populations involving plutonium and americium. Also, studies investigating the carcinogenicity and other toxic effects of plutonium, but involving high doses in controlled laboratory conditions, will be evaluated to see if any of the results might be applicable to conditions at OU No. 2. In addition, limited toxicity tests may be conducted on target organisms to assist in determining what concentrations might be toxic.

2.4.4 Risk Analysis

The risk posed by contaminants released from OU No. 2, given the "no action" alternative, will be assessed using one or more techniques. Five different methods of analyzing risks to the environment from contaminants present at OU No. 2 are discussed in this Subsection:

1. Comparing exposure point concentrations to published criteria or doses with known adverse effects
2. Comparing toxicity test data on laboratory organisms (e.g., fathead minnows) to actual populations in the RFP environment
3. Comparing on-site populations of plants or animals existing in contaminated areas to uncontaminated or "reference" areas
4. Using a quantitative human health risk assessment approach (intake rates, reference doses, etc.) for a limited number of organisms
5. Applying quantitative fault/event tree analysis.

The first method, referred to as the quotient method, involves comparing the concentrations of a contaminant at known exposure points to a published criteria or regulatory standard (ARARs), or to a dose known to cause adverse or toxic effects (for example an LC-50). As discussed in previous sections, the risk from chemical or radiological contaminants to populations in nature, based on toxicity tests or epidemiological data, are not available in many cases. Therefore, the quotient method can be used, employing criteria that have been established from the toxicological literature.

A second risk analysis method involves comparing data from laboratory toxicity tests on standard species, such as fathead minnows, to fish populations in the creeks and ponds near OU No. 2. Appropriate correction factors must be applied to incorporate variability among species, life stages, and so forth, and account for differences between conditions in the laboratory and in the natural environmental. This method will yield an indication of what concentration of a contaminant will be a safe level, below which no adverse effects are expected to occur. A logical refinement of this method would be to conduct toxicity tests on native species using water or soil from the OU No. 2 area, simulating environmental conditions as much as practical.

A third method is based on comparing on-site populations in known or expected contaminated areas to similar populations at reference (upgradient uncontaminated) areas. Population parameters (e.g., growth rates, reproduction rates, and mortality rates) or community parameters (e.g., species diversity, standing crop, and productivity) are used to assess the differences between the populations in impacted and unimpacted areas. At the concentrations of contaminants expected in the RFP ecosystems, this method may not be sensitive enough to unequivocally determine consequences.

In some cases, a quantitative assessment of toxicity will be used, similar to the risk analyses used for human health risk assessments (a fourth method). However, the necessary data on such factors as intake rates and reference doses will limit this approach to a few animals. Under this method, noncarcinogenic effects are assessed by comparing reference doses (acceptable intakes) to exposure-specific intake rates for each contaminant being addressed. This method provides a "hazard index" for each contaminant within a specific transport media such as water.

If the ratio of the daily intake to the acceptable intake exceeds 1.0 (unity) for the defined exposure scenario, there is an indication that the exposed receptor may be subject to an adverse impact and that further investigation should be undertaken. If the ratio is below unity, it is generally assumed that no adverse impact will occur.

It should be emphasized that the hazard index is not a mathematical prediction of incidence or severity of effects, as is the case with carcinogenic estimates. It is simply a numerical index to help identify potential exposure problems.

The numerical indices will then be used to calculate population risk (the number of cases resulting from one year of exposure, or the number of cases occurring in one year) and the standardized mortality ratio (the number of deaths or cases of disease observed in an exposed group divided by the number that would be expected if the group experienced the same mortality or morbidity rate as the general population). Equations for these calculations are as follows:

$$\textit{Population Risk} = \textit{Individual Risk} \times \textit{Population Exposed}$$

T

$$\textit{Standardized Mortality} = \frac{\textit{Incidence Rate in Exposed Group}}{\textit{Incidence Rate in General Population}}$$

A

A fifth method for analyzing risk that will be considered for possible use at OU No. 2 is the use of fault/event tree analysis. This process examines the release scenarios, pathway analyses, and possible consequences to the ecosystems in a step-wise sequence. It uses logic diagrams in phased scenarios to which probabilities can be assigned. This is a quantitative probability method in which uncertainties can also be quantified.

2.4.5 Uncertainty Analysis

All risk estimates are dependent on numerous assumptions and the many uncertainties that are inherent in the EE process. In any evaluation of the level of risk associated with a site, it is necessary to address the level of confidence or the uncertainty associated with the estimated risk.

Uncertainties are associated both with the toxicity information (e.g., hazard identification and dose-response assessment) used to establish acceptable levels of exposure and the for populations associated with the RFP and OU No. 2. Consequently, factors that may significantly increase the uncertainty of the EE results will be identified and addressed in a qualitative and, where possible, quantitative manner.

Three qualitatively distinct sources of uncertainty endemic to any EE are: inherent variability, parameter uncertainty, and model error. It is essential to distinguish between these uncertainty parameters since they differ with respect to feasibility of quantification and degree of possible reduction through research or environmental monitoring (Barnthouse et al., 1986).

Inherent Variability

Constraints on the precision with which variable properties of the ecosystem can be measured will limit the precision with which it will be possible to predict the ecological effects of stress. The concentration of a constituent in a medium varies unpredictably in fate and transport (space and time) because of essentially unpredictable variation in meteorological parameters such as precipitation and wind direction. The spatiotemporal distributions and sensitivities to stress of the target species in nature are similarly variable. This variability can be quantified for many characteristics of the physical environment that influence the constituent's environmental fate (Barnthouse et al., 1986). For the OU No. 2 EE, actual analytical data will be used as the estimates of constituent soil and water concentrations. Variable biological aspects of the ecosystem will be more difficult to quantify.

Parameter Uncertainty

Errors in parameter estimates may introduce additional uncertainties into the EE. Parameter values from the scientific literature may be estimated from structure-activity relationships or from taxonomic correlations that are not corrected for site-specific parameters. In addition, direct laboratory measurements may be subject to errors. Unlike inherent variability, however, uncertainties due to parameter error may be reduced by increasing the precision of measurements or by replacing extrapolated parameter estimates with direct measurements where possible.

Model Errors

Model errors will constitute the least tractable source of uncertainty in the EE. Major sources of model error can be: (1) using a small variable to represent a large number of complex phenomena; (2) choosing incorrect functional forms for interactions among variables; and (3) setting inappropriate boundaries or limits on the model universe (Barnthouse et al., 1986). Although these errors cannot be completely eliminated from the EE, one of the EE objectives will be to reduce them as much as possible.

2.5 CONCLUSIONS

The results of the EE will be presented in a clear, concise manner. The conclusions will be organized around the risks posed by contaminants from OU No. 2 to specific plant and animal species (e.g., benthic macroinvertebrates). As stated previously, the final conclusions will be based on lines of evidence from several assessment techniques. The conclusions section will include a discussion of EE objectives to determine if they were accomplished. Also, the uncertainties associated with the risk assessment will be presented, along with an evaluation of how these uncertainties influence the conclusions. The EE will determine whether OU No. 2 presents an unacceptable environmental risk unless remedial actions are undertaken.

3.0 ENVIRONMENTAL EVALUATION WORK PLAN IMPLEMENTATION

This section describes ten different tasks under which the EE will be organized, staffed, managed, and performed. This task structure will be employed as the principal vehicle for scheduling and budgeting of the entire EE process. Program flexibility will be required as the nature and scope of any particular task may need to be modified depending on the results of the review of existing data, field investigations, and the sampling and analysis program. The tasks are subdivided into those dealing with project organization and those involving actual performance of the EE.

3.1 PROJECT ORGANIZATION AND MANAGEMENT

The tasks described in this section pertain to project organization, quality assurance and quality control, health and safety, documentation, and control of schedules and costs. Tasks pertaining to EE performance are described in Subsection 3.2.

3.1.1 Task 1: Project Organization and Management

The EE will be a multidisciplinary undertaking staffed by specialists from several different scientific and technical disciplines. The project will be managed by a Task Manager who will have primary responsibility for the following functions:

- Coordination of all ten EE tasks
- Selection and assignment of personnel
- Cost estimating, scheduling, and schedule/cost control
- Tracking of documentation and preparation of the EE report (EER)
- Liaison with EG&G and submittal of progress reports and other documentation
- Coordination with whatever contractors are performing the OU No. 2 RFI/RIFS.

The EE staff will include, but not necessarily be limited to, specialists in the following disciplines:

- Surface water and ground water hydrology

- Soils science/geology
- Terrestrial ecology
- Aquatic ecology
- Environmental toxicology
- Climatology
- Computer modeling
- Health and safety
- Quality assurance
- Costs/schedule control.

Representatives of each of the technical and scientific disciplines will work together as a team to characterize the OU No. 2 site and the surrounding area that could possibly be affected by OU No. 2 contaminants. The exact geographic scope of the investigation cannot be determined until existing literature has been reviewed and some field work has been undertaken. It is likely that environmental contamination resulting from OU No. 2 releases will "overlap" with contaminants from other operable units. However, natural ecosystems are not organized along operable unit boundaries. The scientific and technical team will identify the geographic scope, the location of surface and ground water sources of contamination on or near the site, the types and distribution of ecological habitats, and the nature of possible air, water, and soil pathways. The details of these investigations are described in the methodology discussion in Section 2.0.

The EE for OU No. 2 cannot be conducted in a vacuum. Throughout the EE process, it will be important to coordinate efforts with those who are simultaneously performing the RFI/RIFS and the health risk assessment. It will also be necessary to coordinate with those responsible for EEs or other types of investigations at OUs in close proximity to OU No. 2. Presumably, these coordination efforts will be expedited by EG&G personnel.

3.1.2 Task 2: Quality Assurance and Quality Control (QA/QC) Program

The EE will be implemented under the Quality Assurance Program Plan (QAPP) and the project-specific Quality Assurance Task Plan (QATP). The QATP is consistent with the draft QAPP prepared for the Environmental Restoration Program at the RFP (Rockwell International, 1989c). It is likely that this has been updated by an EG&G contractor. The

QATP will describe the QA/QC policy and protocols necessary to achieve the required data quality objectives (DQOs) stated in the EE Sampling and Analysis Plans.

The QAPP and QATP program will address such items as:

- Project organization
- Authorities and responsibilities
- QA objectives
- Sampling and analysis procedures
- Custody of samples
- Analytical procedures
- Data validation reporting
- Internal quality control
- Data assessment procedures
- Quality assurance reports
- Auditing.

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3.1.3 Task 3: Health and Safety Plan

A Health and Safety Plan will be developed for the EE prior to the commencement of any field investigations or field sampling. Because OU No. 2 contains 18 solid waste management units (SWMUs) [or individual hazardous substance sites (IHSSs)], personnel involved in the actual field work and sampling will be required to have 40 hours of Occupational Safety and Health Administration (OSHA) training. They will be instructed in the use of personal protective equipment (PPE) appropriate for the level of hazardous substances expected to be found. The Health and Safety Plan will also address decontamination procedures for personnel and equipment.

In addition, all personnel assigned to field activities at OU No. 2 will receive two hours of health physics training. This training will address the types of radionuclides expected at the unit and the potential effects of human exposure. Appropriate precautions and protective measures for those potentially exposed to radiological hazards will be incorporated into the Health and Safety Plan.

3.1.4 Task 4: Project Documentation

The EE will produce multiple types of documents and documentation requirements: EEW modifications; progress reports; minutes of meetings with EG&G; field data; photographs; existing reports and other data; records of telephone conferences; scientific literature; sampling and analytical data; and the draft and final EE reports. To the extent practical, all EE documentation will be retained in the same location for easy access by members of the project team.

3.1.5 Task 5: Scheduling, Costing, and Schedule/Cost Control

Personal computer-based software systems will be used to prepare schedules and assess cost/schedule performance. Basic information for the cost/schedule tracking software will be provided by downloading from the IT Job Tracking System (JTS). The JTS is an IBM System/38 which provides weekly current-period and job-to-date reports for labor, materials, equipment, outside services, and analytical costs.

The scheduling software to be employed for the EE is a Super Project Planner (SPP). The SPP is a personal computer-based planning system which integrates schedule, resource allocation, and budget. The Task Manager will establish a schedule allocating resource personnel and time requirements to each of the EE tasks. The planned costs for the EE will be established and a budget calculated for each activity and each task.

A performance measurement system which measures the percent complete and the actual costs of each activity against the budgeted costs will be utilized throughout the EE. Variances in actual costs and schedule when compared to the projected baseline will then be accommodated.

3.2 ENVIRONMENTAL EVALUATION

The tasks described in this section address data evaluation and analysis, field investigations including field sampling and analysis, the ecological risk assessment, and the format and content of the EE report. These tasks may need to be modified depending on the nature and extent of the existing database.

3.2.1 Task 6: Review of Existing Information

The depth and breadth of existing data and site information pertaining to OU No. 2 and its immediate vicinity is not currently known. Several reports, including the Phase 1 RFI/RIFS and the Phase II RFI/RIFS work plan are available for OU No. 2. There are also monthly and annual RFP Environmental Monitoring Reports as well as some rather generic information on plant and animal species and habitats including wetlands.

As the list of references included in this EEW indicates, there are also a number of sources of useful information in the scientific literature and in reports prepared by Colorado State agencies and universities. The collection and review of the existing database on wetlands and floodplains, threatened and endangered species, meteorology, geology, soils, hydrogeology, hydrology, geomorphology, and other topics will in itself be a significant task. It will guide how each of the subsequent tasks are to be conducted.

3.2.2 Task 7: Data Evaluation and Analysis

As discussed in EEW Subsection 2.1, site-specific information and the scientific literature will be reviewed and analyzed to provide a comprehensive data source for the EE. The data evaluation and analysis tasks will review the existing database to determine, among other things, the following:

- Identification and concentration of contaminants of concern (organics, heavy metals, and radionuclides)
- Site-specific characteristics (climatology, surface water, ground water, soils, geology, hydrology, geochemistry, and terrestrial and aquatic ecosystems)
- Adequacy of data and additional data needs.

The nature, extent, and scientific credibility of the existing database will, in great part, dictate the parameters for the field investigations in Task 8.

3.2.3 Task 8: Field Investigations (Including Field Sampling)

The methodological approach to field investigations, including field sampling and analysis, is described in detail in Subsection 2.2.4 and Appendix C. Field investigations will be adequate to determine: (1) contaminant source characterization; (2) exposure pathway characterization; (3) presence, absence, and distribution of biological receptors, and (4) assessment of toxicity or stress on terrestrial and aquatic ecosystems. While data required to address items (1) and (2) is assumed to be available from the Phase I and II RFI/RIFS investigations, some additional data (e.g., information on sediments) will need to be collected in the field. Also, additional data will need to be developed for flora and fauna in order to develop a thorough understanding of population dynamics. Specifically, information will be developed in the field on species diversity, biomass, sensitive habitats, and food webs. All these data will be needed to determine populations at risk.

Field investigations will include each of the items addressed in Section 2.2.4:

- Qualitative field surveys (including sensitive habitats such as wetlands or riparian vegetation)

- Comparative ecology studies (involving comparisons of impacted and nonimpacted reference sites)

- Sampling of periphyton, benthic macroinvertebrates, and vegetation.

Once Tasks 6 and 7 have been completed and the additional data needs specified, a detailed field sampling plan will be developed. The plan will specify sampling techniques, field instrumentation, and data management. It will also be integrated with the Health and Safety Plan. A field sampling plan is not possible to formulate until the existing database has been reviewed and evaluated and some preliminary field work has been accomplished. However, the following factors will be considered and specified in the field investigation and the sampling plan where they are applicable:

- Number and qualifications of participating personnel
- Optimal dates for investigation
- Times of day
- Weather conditions
- Survey units
- Observation points
- Methods of personnel transportation
- Lists of equipment and supplies
- Photographic needs
- Sample management

- Field data forms
- Summary data forms
- Sampling requirements
- Statistical analysis requirements
- Data filing.

3.2.4 Task 9: Ecological Risk Assessment

The assessment of risk to terrestrial and aquatic organisms and ecosystems will be accomplished through the environmental analysis, toxicity assessment, and risk characterization described in EEW Subsections 2.2, 2.3, and 2.4. The environmental analysis will characterize ecosystems, populations at risk, and potential contaminant pathways. The ecosystem characterization will include biotic resource inventories (wildlife, vegetation, and aquatic organisms). While population information exists for species present at the RFP, the amount, type, currency, and reliability of the database will vary by species from place to place. Habitats will be characterized considering: direct or indirect exposure to contaminant transport; physical disruption of ecosystem processes; physical disruption of habitat due to site design or operation; and other stresses not related to the site or its constituents, e.g., extreme weather conditions. Food webs will be selected according to the five major trophic levels:

- Primary producers
- Primary consumers (herbivores)
- Secondary consumers (omnivores)
- Tertiary consumers (carnivores)
- Decomposers.

Populations at risk will be determined by analyzing the distribution of plants and animals within, upgradient, and downgradient of OU No. 2. Potential ecological impacts will be assessed using several lines of evidence which are described in detail in EEW Subsection 2.2. Target or indicator species will be evaluated to determine site specific constituent impacts.

The risk characterization will provide an evaluation and a summary of all the information that has been collected and present this information in an understandable manner. The risk characterization will also include selection of criteria for organic chemicals, heavy metals, and radionuclides. It will include both a qualitative and a quantitative analysis of risks together with their probability of occurrence (see EEW Subsection 2.4.4). Further, the risk analysis will include an analysis of uncertainties that are intrinsic to the EE process (EEW Subsection 2.4.5).

This task will also summarize the results of the ecological risk assessment to determine if the objectives were accomplished and if there are uncertainties that have not been resolved.

3.2.5 Task 10: Environmental Evaluation Report

The preparation of the EER will necessitate the accomplishment of three steps or subtasks:

- Submittal of a draft EER
- Review and comment by EG&G
- Response to EG&G comments
- Incorporation of responses to comments and submittal of a final EER.

The format and content of the EER is addressed in EEW Section 4.0. The major steps in developing the EER are illustrated in Figure 2. A suggested EER outline is included in Appendix B.

FIGURE 2

MAJOR STEPS IN DEVELOPING THE ENVIRONMENTAL EVALUATION REPORT FOR RFP OU NO. 2

IDENTIFY CONTAMINANTS OF CONCERN

- Organic chemicals
- Heavy metals
- Radionuclides

DETERMINE CONCENTRATIONS AT EXPOSURE POINTS

- Fate and transport models
- Field measurements

CONDUCT EXPOSURE ASSESSMENT

- Exposure routes
- Populations at risk
- Exposure period/intake

PERFORM TOXICITY ASSESSMENT

- Toxicity profiles
- Toxicity values
- Uncertainties

CHARACTERIZE THE RISK

- Comparison to criteria
- Toxicity
- Comparative ecology
- Biomarkers

4.0 FORMAT AND CONTENT OF THE ENVIRONMENTAL EVALUATION REPORT

The EER will have three basic uses. It will be used to:

- Determine the nature and severity of the environmental risk resulting from existing contamination conditions at OU No. 2 without remedial action (the "no action" alternative)
- Determine the need for remedial action and provide information needed to evaluate potential environmental impacts of remediation alternatives
- Prepare appropriate environmental documentation needed to comply with the National Environmental Policy Act (NEPA).

The introductory sections to the EER will define the objectives and scope of the EE investigation and generally describe the physical and biological characteristics of the site. Information from prior studies, such as the OU No. 2 RFI/RIFS field investigations, will be used to: identify the contaminants of concern; assess the sources and fate of transport mechanisms for these contaminants; and describe the logical pathways and receptor species or communities.

The characterization of risks in the EER (see EEW Subsection 2.4) will be based on several lines of scientific evidence. For example, one line of evidence will be based on comparisons of contaminant concentrations to organic chemical, heavy metals, or radionuclide criteria in addition to toxicity data from the literature. Another line of evidence will compare biological communities at on-site stations to reference off-site stations. Thus, there will be subsections of the report that do not exactly align with those shown in Figure 2.

Since the assessment of risk to biological receptors is largely based on the weight of the evidence supporting particular conclusions, a summary section will be included in the EER. This section will present the various lines of evidence supporting (or failing to support) each basic conclusion and discuss the associated uncertainties. The factors that limit or prevent development of definitive conclusions will be described and the degree of confidence in the data used will be presented.

The EER will be structured and written to facilitate its use by a diverse audience: technical specialists, scientists, administrators, and the general "lay" public. Portions involving technical detail, such as explanations of methodologies or fate and transport models, will be presented in appendices. An Executive Summary will be prepared to briefly present the basic information contained in the ecosystem characterization, exposure, toxicity, and risk assessment portions of the report and describe how this information supports the risk characterization conclusions. A glossary will be included to define technical terms along with a list of acronyms. A complete list of references, including the scientific literature cited, will also be included. Appendix B contains a suggested OU No. 2 EER outline.

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APPENDIX A

EXAMPLE TOXICOLOGICAL PROFILE

1,1-DICHLOROETHANE

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1,1-DICHLOROETHANE

A.1.0 INTRODUCTION

The chlorinated ethanes are produced in large quantities and used for production of tetraethyl lead and vinyl chloride, as industrial solvents, and as intermediates in the production of other organochlorine compounds. All of the chlorinated ethanes studied have been found to be mildly toxic, with toxicity increasing with the degree of chlorination. Density and melting point also increase with halogen substitution. Conversely, both water solubility and vapor pressure descrease with halogen substitution.

1,1-dichloroethane has the molecular formula $C_2Cl_2H_4$ and a molecular weight of 98.96. Also known as ethylidenechloride or ethylidenedichloride, pure 1,1-dichloroethane has a vapor pressure of 182 mm Hg, a water solubility of 5,500 mg/l (Archer, 1979) and a log K_{ow} of 1.79 (Valvani et al., 1981). Based on these data, this compound would be expected to partition into the water column in aquatic ecosystems, rather than adsorb to suspended particulates. It has an estimate half-life in water of one to five days and a half-life in air of one and one-half months (Callahan et al., 1979); no half-life value for 1,1-dichloroethane in soil could be located in the available literature. However, evaporation is expected to be the predominant loss mechanism from the soil surface. The half-life for soil evaporation should be longer than its evaporation half-life from water. In subsurface soil, the loss of 1,1-dichloroethane through biodegradation is expected to be insignificant (Wilson et al., 1983). Therefore, 1,1-dichloroethane may persist in soil and is expected to be removed primarily through leaching into ground water.

Halogenated hydrocarbons have been identified in 80 domestic water supplies by Symons et al. (1975). 1,1-dichloroethane was among the compounds identified in finished water of several metropolitan areas (Coleman et al., 1976; Kopfler et al., 1976).

A.1.1 ENVIRONMENTAL TOXICITY

Few animal studies have been conducted with 1,1-dichloroethane. In a study conducted by Larson et al., three dogs were intubated with 200 mg/kg body weight (bw) for six days/week for eight weeks in order to observe the effects on the adrenal gland. All three animals survived and none had significant histopathology of the adrenals. Other parameters of toxicity were not reported. Rats given 1,1-dichloroethane in a corn oil carrier via gavage exhibited depressed body weights at dosages greater than 1,000 mg/kg bw (NCI, 1978). Males appeared susceptible to lower doses than females. However, these studies were considered too limited in their assessment of toxicity criteria to be useful in risk assessment.

Of several species tested, cats appeared to be the most sensitive to inhaled 1,1-dichloroethane. Blood urea nitrogen levels were immediately elevated during post-exposure and peaked at approximately three times the normal level. Histopathological examination of the cats revealed renal tubular dilation and degeneration, indicating kidney damage (Hofmann et al., 1971). Based on data from this study and another by Torkelson and Rowe (1981), a no observed effect level (NOEL) of 500 ppm (2,025 mg/m^3) can be suggested for subchronic exposure in rats, cats, guinea pigs, rabbits, and dogs.

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The only study of chronic oral toxicity to 1,1-dichloroethane was reported in the NCI carcinogenicity assay (NCI, 1978), in which 50 male and 50 female rats and mice were intubated with the compound in a corn oil carrier. Treatments were administered for five days/week for three weeks, followed by one dose-free week and three additional treatment weeks over the 78-week treatment period. All groups of male and female rats exhibited a hunched appearance, abdominal urine stains, labored breathing, wheezing, and nasal discharge. Although there were no definitive signs of 1,1-dichloroethane toxicity in physical appearance or behavior of the mice, survival of both males and females was adversely affected.

In Swetz et al. (1974), female rats were exposed to 0, 3,800, or 6,000 ppm 1,1-dichloroethane via inhalation for seven hours/day on days 5 to 15 of gestation. The highest dose resulted in an increased incidence of delayed ossification of sternebrae in the newborn rats.

A.1.2 HUMAN TOXICITY

At one time, 1,1-dichloroethane was used as an anesthetic, with an anesthetic pressure of 0.026 atmospheres, -105,000 mg/m^3 (Miller et al., 1965). The ability of the compound to induce cardiac arrhythmias caused discontinuation of its use as an anesthetic (Browning, 1965). It is probable that human exposure to sufficiently high levels of 1,1-dichloroethane would cause central nervous system (CNS) depression and respiratory tract and skin irritation, as is the case in exposure to many other chlorinated aliphatics. Although the EPA (1980, 1983) stated that no information was available on unusual sensitivity of any groups to any of the chlorinated ethanes, it was suggested that individuals with liver insufficiency or exposure to other hepatotoxins may be at increased risk. Presumably, individuals with impaired renal function may also be unusually sensitive to exposure to 1,1-dichloroethane. In general, there is a paucity of information regarding the impact of this compound to human health.

A.1.3 CARCINOGENICITY

In the 1978 NCI carcinogenicity assay, female rats demonstrated a significant dose-response relationship in the incidence of hemangiosarcoma. However, male rats showed no significant change in neoplastic incidence that was related to the 1,1-dichloroethane compound. Mammary adenosarcomas were also considered significant in the females, using the Cochran-Armitage test for linear trend in proportions. However, significance was not demonstrated using the Fisher Exact test. In female mice, the Cochran-Armitage test showed a positive dose-response relationship in the incidence of benign endometrial stromal polyps that was coincident with results of the Fisher Exact test. NCI concluded that this evidence suggested the possible carcinogenic potential of 1,1-dichloroethane but deemed it inconclusive.

Weisburger (1977) reviewed NCI's bioassays of several halogenated aliphatics and noted that 1,1-dichloroethane and tetrachloroethylene both induced hepatocellular carcinoma in mice. Although the incidence of this type of tumor was not considered significant, the similarity in lesions produced by other members of this chemical class raised a concern that the marginal results may well be biologically important. Nevertheless, neither IARC nor the Carcinogen Assessment Group of the EPA has classified 1,1-dichlorochloroethane as to carcinogenicity, placing it into Group D -- Not Classified chemical.

APPENDIX B

SUGGESTED OUTLINE FOR THE RFP OPERABLE UNIT NO. 2

(903 PAD, MOUND, AND EAST TRENCHES AREAS)

ENVIRONMENTAL EVALUATION REPORT

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APPENDIX B

SUGGESTED OUTLINE FOR THE RFP OPERABLE UNIT NO. 2 (903 PAD, MOUND, AND EAST TRENCHES AREAS) ENVIRONMENTAL EVALUATION REPORT

EXECUTIVE SUMMARY

LIST OF ACRONYMS

1.0 INTRODUCTION

1.1 OVERVIEW

- General problem at site
- Site-specific objectives
- Scope

1.2 SITE BACKGROUND

- Site environmental description
  - Topography
  - Hydrogeology
  - Ecology
  - Meteorology
- Site Map
- General History
  - Ownership
  - Operations
  - Known or potential contaminants
  - Land use
- Significant site reference points
- Geographic location relative to off-site areas of interest
- General sampling locations and media

1.3 SCOPE OF ENVIRONMENTAL EVALUATION

- Assignment and rationale
- Overview of study design

1.4 ORGANIZATION OF ENVIRONMENTAL EVALUATION REPORT

2.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

2.1 GENERAL CONSIDERATIONS PERTAINING TO THE RFP

- Historical information
- Surveys and field investigation
- Other reports and data

2.2 OPERABLE UNIT NO. 2

- Area- and media-specific collection strategy
- Data from site investigations
  - Summary of methods
  - Summary of quality control
  - Data analysis
- Uncertainties, limitations, gaps in quality of data collection or analysis

2.3 SUMMARY OF CHEMICALS OF POTENTIAL CONCERN

- Criteria
- Receptors

3.0 EXPOSURE ASSESSMENT

3.1 CHARACTERIZATION OF EXPOSURE SETTING

- Physical setting
  - Climate
  - Vegetation
  - Soil type
  - Surface hydrology
  - Ground water hydrology
  - Ecological habitats (e.g., forested areas, floodplains, wetlands)
- Potentially exposed populations
  - Nature and extent of contamination
  - Assessment of sensitive environments
  - Habitats potentially affected by site contamination
  - Populations potentially exposed to contaminants

3.2 IDENTIFICATION OF EXPOSURE PATHWAYS

- Sources and receiving media
- Fate and transport in release media
  - Physical
  - Biological
  - Decomposition rates and products
  - Bioaccumulation potential
- Exposure points and exposure routes

3.3 POTENTIAL FOR EXPOSURE

- Seasonal or climatic variations
- Site-specific geophysical, physical, or chemical conditions

3.4 QUANTIFICATION OF EXPOSURE

- Exposure concentrations
- Route of intake

3.5 CONTAMINANT CONCENTRATION ASSESSMENT

- Exposure concentration versus criteria/standards
  - Water quality
  - Air quality
  - Soils
- Identification of Uncertainties
- Summary of Exposure Assessment

4.0 ECOLOGICAL EVALUATION

4.1 AQUATIC ENVIRONMENTS

- Periphyton
  - Algal types, species diversity, standing crop (biomass), productivity
- Benthic Macroinvertebrates
  - Abundance, species diversity, tolerant/intolerant species, biomass, fecundity

4.2 TERRESTRIAL ENVIRONMENTS

- Grassland Flora
  - Herbaceous and shrub species, cover class, biomass, primary production, dominant species
- Wetland Flora
  - Abundance, species diversity, biomass, production, visible evidence of stress

4.3 EVALUATION OF POTENTIALLY AFFECTED HABITATS

4.4 EVALUATION OF POTENTIALLY AFFECTED POPULATIONS

4.5 SUMMARY OF ENVIRONMENTAL EVALUATION

5.0 TOXICITY ASSESSMENT

5.1 PROFILE OF TOXIC EFFECTS FOR CONTAMINANTS OF CONCERN

5.2 EXPOSURE PERIODS AND INTAKE

5.3 TOXICITY VALUES

5.4 UNCERTAINTIES RELATED TO TOXICITY INFORMATION

5.5 SUMMARY OF TOXICITY INFORMATION

6.0 RISK CHARACTERIZATION

6.1 SUMMARY OF RISKS

- Based on criteria/standards
- Based on comparative assessment
- Based on toxicity assessment

6.2 OVERALL SCENARIO OF RISK ASSESSMENT

7.0 SUMMARY

7.1 CHEMICALS OF POTENTIAL CONCERN

7.2 EXPOSURE ASSESSMENT

7.3 ECOLOGICAL EVALUATION

7.4 TOXICITY ASSESSMENT

7.5 RISK CHARACTERIZATION

APPENDIX C
ENVIRONMENTAL EVALUATION
SAMPLING PROCEDURES

DRAFT

APPENDIX C
SAMPLING PROCEDURES

C.1.0 INTRODUCTION

Site-specific field sampling procedures will be developed following protocols recommended by EPA (EPA, 1987a, 1989a, 1988a) and the U.S. Fish and Wildlife Service (1981a, 1981b) and already being used at the RFP (DOE, 1990). The Quality Assurance Task Plan and Data Quality Objectives developed for the RFI/RIFS program and standard operating procedures for current field operations will be followed (Rockwell International, 1989a, 1989c). Sampling procedures will also conform to existing and new health and safety plans, sample and waste management protocols, and EE-specific data quality objectives (Rockwell International, 1989b; EPA, 1987c; DOE, 1990a).

Sampling procedures for the EE of Operable Unit No. 2 will generally have the following components:

1. Perform a reconnaissance survey to thoroughly familiarize the project staff with site elements, topography, drainages, and habitats.
2. Determine the specific sampling methods for habitat type, species of vegetation and animal life, or tissue collection.
3. Choose appropriate sampling periods, locations, and frequencies.
4. Select proper equipment and prepare field data forms for surveying and collecting samples.
5. Collect and preserve sample if further analysis is required.
6. Determine laboratory analysis procedures and techniques.
7. Determine reporting and health/safety requirements.

The sampling protocol will be specific for the type of habitat, community, or species of animal or plant being sampled. Specific examples are given below for the following three ecosystem components that have been identified as sensitive to contaminants from in OU No. 2:

- Vegetation
- Benthos
- Periphyton

C.2.0 VEGETATION

The RFP is situated in an area of high plains grasslands with a variety of vegetation types (EPA, 1980; DOE, 1990a). Vegetation has been identified as a mechanism for resuspension of soil contaminants in areas contaminated from OU No. 2, plutonium in particular (Rockwell International, 1986). Vegetation cover, a constant feature on the plant site, will be used as an indicator of general site conditions. Vegetation will be sampled specifically for contaminant concentrations and as a transfer medium into the herbivore food chain. The following seven elements relate to vegetation sampling.

1. General Reconnaissance -- The 903 pad area, mound area, and east trenches area will be traversed on foot to determine the general vegetation types, including wetlands and riparian zones. Maps, aerial photographs, and results of the Phase I and II field investigations will be used to select features. Plant species will be noted and conditions of growth, vigor, productivity, and range condition will be qualitatively assessed. Both reference and on-site sampling areas will be selected and sampling locations determined.

2. Sample Periods, Locations, and Frequency -- Vegetation at this altitude, about 6,000 feet, should be sampled during the active growth period from about June 15 to August 1, depending on weather conditions during the spring and early summer. Wetland and riparian zone vegetation should be sampled from about August 15 through September 15 since the phenology of these types occurs later in the season. The vegetation transect surveys and clipping plots (sampling) will be conducted concurrently. The sample locations will depend on the initial reconnaissance. Sample adequacy formulas will determine the number of samples to be taken. Grassland sampling will be conducted during the growing season, after the warm season grasses have started growth and maturation.

3. Specific Sampling Methods -- The recommended method for sampling a grassland with few shrubs is to use one-meter-square plots along transects that are randomly stratified according to vegetation types. Plant species will be recorded in each plot and the cover for each estimated to the nearest

percent. Dense shrub vegetation, if it occurs near OU No. 2, will be surveyed using linear plots (2 by 10 meters). Clipping plots for tissue analysis will be either 1.0- or 0.25-meter-square plots. Each plant species will be placed into separate bags, dried, and analyzed according to protocol appropriate for CERCLA and RCRA sites (EPA, 1987a).

4. Equipment -- The equipment needed for vegetation sampling includes:

   - Field forms for recording cover and clipping plot data
   - Thirty meter tape
   - One and 0.25-meter-square frames
   - Meter rulers
   - Clippers
   - Paper sacks and indelible marker
   - Plastic bags
   - Cooler.

5. Sample Preparation or Preservation -- The clipped vegetation samples will be placed in paper sacks by species, labeled, placed in plastic bags, and put in a cooler for transport to a laboratory.

6. Laboratory Analysis -- Vegetation samples will be air- or oven-dried. Samples will be analyzed by EPA certified laboratories, generally following CLP statements of work for organic and inorganic analyses. Detection levels for analytical work will be based on the data quality objectives.

7. Reporting -- The vegetation survey plots will be analyzed by plant species for cover, frequency, and/or density of grass and herbaceous species and shrub species. The results of the analytical tests will be summaried by species, location, and contaminant. The results will be tabularized.

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C.3.0 PERIPHYTON

The periphyton communities at reference and test sites will be monitored using standardized artificial substrate samplers suspended in a water column at sampling locations. Clean samplers will be placed at each sampling location and exposed for four (4) weeks. Water quality parameters such as temperature, pH, as well as specific conductivity, and water depth and velocity, will be recorded at least weekly. The periphyton will be scraped off the artificial substrates at the end of the 4 weeks and analyzed for several population and community indices (see Subsection 2.3.2). Separate samples will be collected and analyzed for contaminant bioaccumulation.

1. General Reconnaissance -- The creeks, ponds, and drainages upgradient and downgradient of OU No. 2 will be surveyed to observe existing periphyton growth and select sampling locations. Periphyton growth and vigor will be qualitatively assessed and field water quality data will be collected.

2. Sample Period, Location, Frequency -- Periphyton samplers will be placed in creeks and ponds during two four (4) week sample periods, correlating generally with high-flow (spring) and low-flow (late summer) conditions. Co-located samplers will be placed at each station for quality control and backup against lost samplers. At least one upgradient reference location and at least two downgradient test locations for creeks and pond habitats will be sampled.

3. Specific Sampling Method -- Artificial substrate samplers holding plastic slides will be placed at each sampling location. Each setup will include a surface-floating and a submerged rack of six plexiglass slides. At the end of the exposure (colonization) period, all periphyton from a given area will be collected for analyzing population and community parameters and measuring bioaccumulation.

4. Equipment -- The equipment needed for periphyton sampling includes:

   - Field data sheets for recording water quality data, site descriptions, etc.
   - Artificial substrate samplers with slides
   - Floats, rope, anchors
   - Water quality field instruments
   - Equipment for determining water depth and velocity
   - Sample containers, labels, bags, and preservative
   - Cooler, ice
   - Decontamination equipment.

5. Sample Preparation/Preservation -- Algae growth will be scraped off both sides of the slide with a neoprene policeman and placed in a container. Separate samples will be taken from the different slides for species identification, biomass determination, chlorophyll "a" concentrations, and contaminant concentrations. Biomass, species identification, and contaminant samples will be held at 4°C prior to processing.

6. Laboratory Analyses -- The chlorophyll "a" samples will be placed in 90-percent acetone. Extracts will be analyzed with a spectrophotometer. Samples for identification will be placed in Lugol's solution and analyzed for taxonomic composition (cell numbers, algal types, etc.). Biomass samples will be dried at 105°C for 12 hours and weighted. Contaminants will be measured by EPA-approved methods.

7. Reporting -- Periphyton population and community parameters, such as cell counts, species richness, species diversity, standing crop (biomass), and

colonization rates will be presented for reference and test sites. Differences in abundance, diversity, and production at reference and test locations will be assessed. Bioaccumulation will be evaluated.

C.4.0 BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates are probably the most common fauna used in ecological assessments of contaminant release. Macroinvertebrates will be collected in creeks and ponds at reference and test sites, primarily in Woman and South Walnut Creeks and in one or more B-series and C-series ponds.

1. General Reconnaissance -- Creeks and ponds will be surveyed using sweep nets, surber samplers, and grabs. Samples will be quickly screened and analyzed in the field for numbers and types of macroinvertebrates. Water quality field instruments will be used to provide some indication of contamination. Reference and test sites will be selected.

2. Sample Period, Location, and Frequency -- Benthic macroinvertebrates will be sampled twice, during low-flow and high-flow periods that also correlate with spring and late-summer seasons. Replicate samples will be collected at each location for quality control and as a measure of natural variation. At least one upgradient and two downgradient sampling locations will be selected for each type of water body (ponds and creeks).

3. Specific Sampling Method -- Surber samplers will be used to sample shallow creek locations (riffles) and an Ekman or Ponar grab will be used in creek pools and ponds. At least triplicate samples will be collected at each location.

4. Equipment -- The equipment needed for benthic macroinvertebrate sampling includes:

   - Field data sheets for recording water quality data, site descriptions, etc.
   - Surber, Ekman, and Ponar samplers
   - Boots and waders
   - Boat and motor or oars for pond sampling
   - Benthic field screen/wash bucket
   - Sample jars, labels, preservative
   - Water quality field instruments
   - Water depth and flow meters (or tapes and stop watch)
   - Cooler
   - Decontamination equipment.

5. Sample Preparation/Preservation -- The entire contents of the surber sampler or grab will be placed into the field screen (No. 35 mesh brass) and washed. The washed sample will be transferred to the sample container and preserved in 70-percent isopropanol or 10-percent formalin. The replicate samples will be labeled with replicate number, sample date and time, and location. Separate samples will be taken for ecological parameters and for contaminant concentrations (bioaccumulation). The contaminant samples will be held at 4°C but not preserved.

6. Laboratory Analyses -- Samples will be washed using a standard No. 60 mesh screen and placed in a large white tray. Organisms will be picked from the debris with forceps using a table-mounted magnifier. Specimens for identification will be preserved in vials of 70-percent isopropanol. Identification and enumeration will be made using dissecting microscopes. Samples used to determine contaminant concentrations will be held at 4°C, processed without any preservative, and shipped to the laboratory on ice or frozen. EPA methods will be used to prepare the organisms for chemical analyses (digestion process) and analyze the sample for inorganic and organic contaminants.

7. Reporting -- The results of benthic macroinvertebrate studies will be presented similarly to the periphyton results. Population and community indices and contaminant concentrations will be compared at reference and test sites. Bioaccumulation results will be evaluated to determine potential for impacting consumer species and higher predators.